COPING MECHANISMS EMPLOYED BY ADULT STUDENTS IN THE USE OF GRAPHING CALCULATORS AND THEIR RELATIONSHIP TO THE LINEAR AND AROUSAL THEORIES OF ANXIETY

By

JERRY W. HICKS

Bachelor of Science
East Tennessee State University
Johnson City, Tennessee
1971

Master of Education
East Tennessee State University
Johnson City, Tennessee
1973

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF EDUCATION
December, 2003

COPING MECHANISMS EMPLOYED BY
ADULT STUDENTS IN THE USE OF
GRAPHING CALCULATORS AND
THEIR RELATIONSHIP TO THE
LINEAR AND AROUSAL
THEORIES OF ANXIETY

Thesis Approval:

____
Thesis Advisor

____

____

____

____
Dean of the Graduate College

DEDICATION

For My Father and Mother

You both showed me the way to do right and always encouraged me to do my best. I know you are sharing this moment with me because you were always part of my life. I honor you for the wonderful parents you were and I wish that you were here to share this special moment…

ACKNOWLEDGMENTS

I wish to express my thanks to my dissertation advisor, Dr. Adrienne Hyle, for her friendship, guidance, and encouragement throughout my doctoral program. My appreciation extends to all members of my dissertation committee, Dr. Kay Bull, Dr. Ed Burns and Dr. Deke Johnson for their willingness to serve on my committee.

I would like to express my gratitude to the University of Maryland and Nikki Kolver for allowing me to conduct research on the University of Maryland campus. My thanks are extended to the administrators and teachers of the University of Maryland who gave so freely of their time, expertise, and the warm welcome they extended to me in their classrooms.

Special thanks to my colleague and good friend Jacqueline Dostal for the long hours of proofreading, encouragement, suggestions, and support. Thanks go to the entire cohort member, but especially to Ryan Schukei, Emma Espinoza and Maggie Detchon.

A heartfelt thanks goes to the best statistician who knows more about statistics than I will ever know, Pat Ballew.

My love and appreciation goes to my life companion, Cheryl, and my children, Gretchen, Jonathon, Heidi and, Jennifer, for managing to stretch their understanding, support, encouragement, and patience throughout this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

Design of the Study

An issue of concern in education today is the performance of students in mathematics (Chiu & Henry, 1990). Students not able to perform mathematical equations are at a distinct disadvantage in most technical areas now. Performance affected by the anxiety that students encounter in mathematics and has been a topic of considerable study to date (Dalton & Hannafin, 1987; Hignite & Echternacht, 1992; Postman, 1992). Brosnan (1998) has continued this research on how anxiety affects student performance in the use of technology.

The basic four-operation calculator with addition, subtraction, multiplication, and division was simple enough to help calculate figures without causing undo stress to students (Texas Instruments Incorporated, 1999). However, the new generation of programmable graphing calculators brings a new dimension into mathematical concepts. The new Texas Instrument TI-83 graphing calculator comes with its own textbook of 19 chapters and over 300 pages describing the possible functions of the calculator (Texas Instruments Incorporated, 1999). The general public as well as the novice calculator user may not take into account that the new calculators can interface with computers, which increases the capabilities of the calculator, but at the same time geometrically increases their complexity and sophistication. This type of modernization makes yesterday's four-operation calculator as obsolete as computers that have not been upgraded at regular intervals. For mathematics students, technology is increasing at a seemingly faster rate than their comprehension of the subject (Worthington & Zhao, 1999).

Mathematics has always had a language of its own and this "language is instrumental in developing mathematical understanding" (Davis, 1999, p. 3). The student without knowing the language of mathematics would quickly be overwhelmed by the terminology of the mathematics course as well as be overwhelmed by the calculator that was designed to facilitate performance in mathematics (Chiu & Henry, 1990). The mathematics student is hampered by the double problem of not only learning the terminology within the framework of the mathematics course, but also interpreting that terminology correctly as a function of the graphing calculator. As the number of mathematical characters and symbols and the use of Greek and Latin numbers and mathematical abbreviations increase, the complexity of interpreting the mathematical language rises (Brace & Brace, 1995). The student is not only the one who must master all terminology in mathematics textbooks, and also the terminology encrypted in the graphing calculators. The complexity of the situation with which that the student must cope and comprehend has therefore increased significantly (Davis, 1999).

Griswold (1994), in his research on anxiety and computer technology, found out the greater the anxiety students encounter, the more their performance will suffer. Most anxiety researchers (Carlson & Wright, 1993; Chui & Henry, 1990; Griswold, 1994; Hembree, 1990) advocate this linear notion theory that states performance increases as anxiety decreases. In other words, as anxiety increases performance will decline.

Not all researchers have reached the same conclusions. In contrast to the linear theory is the arousal theory. Vogel (1994) observed that students with moderate levels of computer anxiety actually exhibited enhanced performance on computer-based versions of the Graduate Record Examinations. Dalgleish (1995) found this true with participants in a computer-based version of the Stroop Color Word test. In the arousal theory, the belief is that some anxiety can be beneficial to performance. If anxiety is low, sleep may occur. However, if the anxiety is very high, the result will be a decrease in performance. In summary, if the anxiety is moderate, performance will increase. Based on Vogel's hypothesis, the fear of technology may have a positive side effect by forcing a student to produce when a greater quantity of stimuli is applied.

These two theories produce a paradox because they contradict each other. From the perspective of linear theory, it is possible or likely to have students perform well with low anxiety. Nevertheless, from the perspective of the arousal theory, it is possible or likely to have students perform well with high anxiety. Linear anxiety theory would predict an inverse correlation between performance and success with math and computer anxiety that is the greater anxiety would lead to reduced performance. In contrast, the arousal theory would predict success for those students with moderate to high math and computer anxiety because the challenge (or arousal) to these individuals serves to positively motivate, therefore increasing performance.

In their research on coping, Folkman and Lazarus (1988) and Schwarzer and Schwarzer (1996) present ways that both anxiety theories can co-exist. A student using appropriate coping skills can perform because they have the flexibility to cope regardless of the amount of anxiety. Researchers agree that a robust arousal theory will extract the most from a diligent student trying to excel (Charness, Schumann, & Boritz, 1992). Students with the heightened level of anxiety were those most eager to ask questions, seek responses from queries, or have more time allotted to finish assignments or complete examinations. Students with a heightened awareness of what was expected of them generally performed better. These students' anxiety levels were increased to the point that they exhibited traits that lead researchers to believe they had mastery of the subject. When using a function of the graphing calculator to solve a problem that was unfamiliar, it is predicted that the students will proceed with much more vigor and perseverance than students less affected by arousal anxiety (Suinn, Taylor & Edwards, 1988).

Statement of the Problem

To increase student success in mathematics, educators have introduced technology, specifically the graphing calculator, into the curriculum. This redesign was intended to make mathematical problem solving easier and to be less time consuming, and allow instruction to focus on conceptual issues, not computation. The bottom line of this change was to increase student performance (Texas Instruments Incorporated, 1999).

At the same time, research on technology notes that technophobia can be the unintended consequence of the introduction of technology into curriculum (Brosnan, 1998). This unintended consequence could be even more detrimental for mathematics education because of the inherent anxiety experienced by many students due to difficulties with technology and with mathematical concepts and terminology (Hembree, 1990). In other words, the technology designed to help all may in fact help only those with positive attitudes towards technology and additionally put those with negative attitudes towards technology at great risk of failure.

These two distinctly different responses to mathematics and computers exist, in all likelihood, because coping strategies allow for the possibility of success under either anxiety theory. Students ultimately determine their fate by whatever coping mechanism they have adopted.

Conceptual Framework

Folkman and Lazarus (1988) define coping "as the cognitive and the behavioral efforts to manage specific external and/or internal demands appraised as taxing or exceeding the resources of the individual" (p. 2). Coping refers to only those adaptational activities that involve effort; automatic behavior involves only a response without effort. Four features identified in this definition are specifically related to the use of the graphing calculator.

The first feature of the graphing calculator is that it is processed-based. That means a graphing calculator is programmed on mathematical procedures (Smith, 1998). The second feature refers to a student being able to manage a process without knowing all the intricacies of graphing calculator technology. The third is the infallibility of technology whereas humans are prone to errors. Lastly mathematics is inherently stressful and coping mechanisms are used rigorously in the concepts and technology to allow students to overcome adversity.

There are two main dimensions of coping strategies. These dimensions of coping are escape-avoidance and attentive-confrontational (Folkman & Lazarus, 1988; Schwarzer & Schwarzer, 1996). For purpose of this study, students using escape-avoidance strategies would seek others reasons why the calculator could not help them with the problem and seek other ways of accomplishing their objective or not do it at all. Their main strategy is "flight;" they run from the problem and avoid assignments with graphing calculators for as long as possible (Glasgow & Reyes, 1998). Denial, a major component of this style of coping, is an excuse to prolong or avoid the completion of the project. Excuses are another example of avoiding the use of the calculator and doing the problem with pencil and graph paper.

Students using attentive-confrontational strategies would actively try to solve the problems with the graphing calculator. These students will "fight" to solve problem by finding ways to use functions of the calculator by graphing, listing, or computing. Attentive-confrontation is the name given to this process as outlined by several noted psychologists (Bandura, Cioffi, Taylor, & Broillard, 1988; Schwartzer & Schwartzer, 1996; Lazarus, 1999). These individuals will actively try to find the root of their problem and overcome it. Students will ask the teacher, parents or other students how to operate a graphing calculator (Waxman & Haung, 1996) and those who learn quickly will automate the process and no longer exhibit coping behaviors.

Purpose of the Study

The purpose of this study, then, is to explore the coping techniques of students and their success. Specifically, in mathematics classrooms using graphing calculators, the following will be done:

1. Document student perceptions about how they cope with mathematics and technology, and document their success.
2. Analyze these perceptions of coping through the lens of escape-avoidance or confrontational coping theory (Folkman & Lazarus 1988).
3. Document other realities revealed.
4. Assess the usefulness of escape-avoidance or attentive-confrontational lens of coping for understanding the phenomenon under study (Folkman & Lazarus 1988).

Procedures

This study will use quantitative data collection and analysis procedures (Creswell, 1994). The first step will be to conduct a two-part inventory designed to assess mathematics anxiety and coping strategies. Responses will then be correlated to determine the relationship between anxiety and coping.

Researcher

I became interested in this field of study when I enrolled in a seminar at the University of Northern Iowa from Dr. Jack Wilkerson, mathematics department head. Dr. John Dossey from Illinois State University, a presenter at the seminar, put forth the question of technology as a source of achievement or anxiety. He used the Third International Mathematics and Science Study (TIMSS) to spur my interest of why the United States at the forefront of the world in technology ranked near the bottom in a mathematics and science test. Since I am a certified math teacher, I questioned why our students were not performing better considering the availability of graphing calculators, which lead to my pursuing this dissertation on this topic. A layperson may not see the connection as readily as I may, because I evaluate technology and the effects this technology has on students on a routine basis.

I, myself, know the frustration of technology because I was not computer literate in the making of the graphs and charts needed to display my statistical data in this dissertation. I sought help from experts in technology and statistical fields to formulate what was necessary.

Data Needs and Sources

To conduct this study, I need to know the anxiety levels of the students participating in this study and the coping strategies they use in mathematics classrooms using graphing calculators. Mathematics students at an upper level school in Suffolk, England and a local university will serve as my primary data sources.

Data Collection

Data were collected from students using a two-part survey (see Appendix A). The first part, adapted from the "Some Dimensions of Mathematics Anxiety: A Factor Analysis across Instruments" (Kazelskis, 1998), determined students levels of anxiety in regular mathematics classrooms. The second part, adapted from Folkman and Lazarus' Ways of Coping Survey (1988), established coping strategies. Specific emphasis on the use of the graphing calculator was addressed and what coping skills were used with the graphing calculator.

The survey used a 5-point Likert scale 1 to 5. One is for not at all, two indicating not very much, three a little, four much and five for very much.

Data Analysis

Mathematics anxiety and coping strategies were correlated using the strategies of Folkman and Lazarus (1988) and Kazelksis (1998). According to Folkman and Lazarus, examining the consistency of coping measures estimated with Cronbach's coefficient alpha produced the reliability factor. This includes psychometric properties of coping with eight scales averaged over five occasions. The properties include mean, standard deviation, skewness, and the alpha-loading factor. Although most internal estimates of coping measures generally fall at the low end of the traditionally acceptable range, the alpha scores (not given in the article) were reported on this questionnaire were quite high.

Validity was in two parts. Face validity was obtained since the strategies described are those that individuals have reported using to cope with the demands of stressful situations (D'Ailly & Bergering, 1992). Construct validity was achieved "since evidence was consistence with the authors theoretical prediction of (1) coping consists of both problem-focused and emotional-focused strategies, and (2) coping as a process" (p. 12).

Kazelskis (1998) presents a factor analysis of the mathematical anxiety survey. He adapted his study from reliable measures including the Mathematics Anxiety Scale (MARS) by Richardson and Suinn (1972), the Mathematics Anxiety Scale (MAS) by Fennema and Sherman (1979) and the Mathematics Anxiety Questionnaire (MAQ) by Wigfield and Meece (1988). A change in the items reflects the need to survey graphing calculators since an inventory did not exist.

In his study, Kazelskis reported validity to be significant in Wigfield and Meece's MAQ questionnaire with "correlations between scores and measures of mathematics ability perceptions, mathematics interest, and mathematics performance (p. 626). Of the eight scales used by the author, seeking social support was the lowest with $r = .17$. This low autocorrelation suggests that the problem-focused forms of coping are strongly influenced by the situational content. The highest value of $r = .47$ suggest that it was influenced by personality.

A reliability score of .89 was reported on the MAS portion of the survey (Kazelskis, 1998). Reliability was obtained by the use of Alpha coefficient for scores on the math test anxiety was reported to be .96. The coefficient then drops to .86 for numerical anxiety, .84 for math course anxiety, .82 for negative affect reaction and finally to a low of .76 for worry (Kazelskis, 1998).

A factor analysis was conducted to ascertain validity and reliability with use of the amended survey for obtaining clear objective evidence to support the problem statement.

Significance of the Study

The significance of this study was to add to the understanding of linear and arousal theory. It also added to the research base on coping, technophobia and mathematics. Instructors with this added knowledge of how students cope with graphing calculators can add to our knowledge of mathematics in the classroom. The comfort and assurance the student gains should add to their performance in mathematical situations.

Research

At present, there is no clear research on anxiety and how it is affected by technology using the graphing calculator. This data added to the body of knowledge and allow reasonable decisions to be made on how to help persons affected by technophobia. The body of knowledge also increased through an understanding of how coping strategies are employed to reduce anxiety in mathematics classes using graphing calculators.

Practice

Data ascertained by the activities of this study would allow the students and teachers to perceive how they cope with technology and graphing calculators. This awareness on the part of educators will allow teachers to observe students having anxiety and suggest ways of coping with technology and graphing calculators. The student needs to believe that the calculator would increase the likelihood that the problem will be worked correctly. The calculator is a time saving device and will help the student if they have confidence in their own abilities. This study helped to determine if training would be necessary for teachers to identify students with anxiety and what coping styles they would use. This may not apply to students who have automatized the calculator behaviors needed to be successful and are no longer using coping strategies.

The important practice is what successful strategy students use. My research allows educators to categorize coping strategies of successful students that can be used as models and develop pragmatic methods. Some students have developed less successful strategies that allow them to cope, but with a decline in performance. My research should help students and educators not only to recognize the different forms of stress and anxiety, but also to develop positive coping strategies for enhanced performance. Mathematics is an abstract subject and educators for years have been trying to bridge the gap between proficiency and excellence with the use of problem solving devices.

Theory

Through the lens of coping strategies (Bandura, Cioffi, Taylor, & Broillard, 1988; Folkman & Lazarus, 1988; Schwartzer & Schwartzer, 1996) of either escape-avoidance or attentive-confrontational behaviors, I will add to the body of knowledge regarding graphing calculators.

Summary

Mathematical anxiety can result from a combination of conceptual frustrations or technological concerns. The purpose of the study is to explore the coping techniques of students in mathematics classes using graphing calculators and their success. The point of reference is whether coping was able to alleviate the anxiety these students incurred. To understand and deal with anxiety as it manifests itself should produce a positive impact on student performance concerning coping strategies (Ma, 1999).

Reporting

Chapter II will present a review of the literature as it pertains to anxiety, technophobia, coping and performance. A through perusal of literature will be necessary to conduct extensive reviews of previous coping and technophobia research.

Chapter III is data presentation.

Chapter IV is analysis and interpretation.

Chapter V is a summary, conclusions, implications and discussions.

CHAPTER II

Literature Review

Calculator use in the schools has become highly commonplace. The National Council of Teachers of Mathematics (NCTM) has recognized this and taken a strong stance in favor of calculator use in mathematics teaching and learning for a number of years. In its position statement on Calculators in the Mathematics Classroom, the NCTM (1986) recommended that teachers, theorists, and test authors integrate calculators into school mathematics at all grade levels and throughout class work, homework, and assessment. The NCTM (1989, 1998, 2000) has furthered this position in more recent years by stating that appropriate calculators must be available to all students at all times, and calculators should be fully integrated into the teaching and the testing of mathematics.

Calculators have clearly become an integral part of the teaching of mathematics and are introduced to students in classrooms across America on a daily basis. However, there has been little research to date on the levels of anxiety the introduction of calculators can cause to students and how they may cope with this "calculator anxiety." This review covers topics related to the purpose of this study, which is to explore the relationship between anxiety, coping, and success in mathematics classrooms using graphing calculators. First, the advantages of calculator usage will be presented. Second, anxiety as it pertains to mathematics, math technology (calculators), and performance will be discussed. Thirdly, age and gender differences in mathematical anxiety and technophobia will be presented. Finally, two major coping strategies, attentive-confrontational and escape-avoidance will be presented to explain the ability of persons to cope with technology (calculator) related anxiety.

Calculator Advantages

There is a wealth of empirical evidence supporting the use of calculators in today's classrooms. In an older study, Hembree and Dessart (1984) combined 79 studies that showed calculators to be invaluable instruments for improving students' perceptions, achievement and attitude. More recent studies have supported the specific use of graphing calculators. For example, Ruthven (1990) found that an experimental group of students using graphing calculators outperformed a traditional group on items requiring students to examine certain graphs and describe them algebraically. Thomasson (1993) discovered that students who were permitted to use graphing calculators both in class and during examinations performed better in terms of achievement than did students who had either limited or no access to graphing calculators. Tolias (1993) compared student use and nonuse of graphing calculators in precalculus classes and found that there were significant differences, favoring the group using graphing calculators, with regard to their relational knowledge of graphical and algebraic procedures and their ability to transfer knowledge between these representations.

Ball (1994), an author of calculus and algebra textbooks and a strong believer in the use of technology in education, has stated his belief in the importance of graphing calculators. He has written books and developed programs for the TI-81 and TI-82 calculators and cites the advantages for using graphing calculators:

> Entire chapters of current textbooks are summarized in one menu of options.... It usually takes weeks or months of instruction to learn how to manipulate matrices.... Suddenly all can be done in a few seconds using a hand-held calculator! (Ball, 1994, p. ix)

Other advantages Ball cites for graphing calculators include, that they are small, are inexpensive, are fairly easy to use, and can perform an amazing number of operations.

For the most part, calculators are meant to enhance advanced mathematical learning and encourage confidence in complex tasks (Ball, 1994; Wheatley, Clemments, & Battista, 1990). Hembree and Dessart (1984) view calculators as facilitative tools that can assist in concept development, aid problem solving, and encourage discovery, exploration, and creativity. Calculators can enhance mathematics learning when they permit the meaning of the problem to be the focus of attention, when they allow the learner to consider a more complex task, and when they lend to motivation and boost confidence (Wheatley, Clemments, & Battista, 1990).

Calculator Disadvantages

Calculators have clear advantages for use in today's mathematics classrooms. However, calculator use is also fraught with many questions and inherent disadvantages.

When calculators were first being introduced into classrooms on a widespread basis, educators were concerned that their use would encourage dependence on calculators and detract or interfere with the learning of basic mathematical skills (Carpenter, Corbitt, Kepner, Montgomery, & Reys, 1981). Calculator use has even been blamed for poor American performance on the TIMSS, a battery of tests in mathematics and science, which was given to students in 41 countries in grades equivalent to the fourth, eighth, and the exiting year of secondary education (Chazan, 1996; Dossey, 1998; Hettinger, 1999).

Reys and Arbaugh (2001) cite four concerns for calculator use in today's mathematics classrooms: 1) Overemphasis and reliance on graphing calculators may encourage students not to think or use their powers of reasoning. 2) The use of calculators for computation may not support students' understanding of mathematical concepts and reasoning about solutions. 3) The use of calculators may inhibit the process of mathematical learning students gain from manual computation or seeing the problem "worked out" on paper. 4) Some students may view graphing calculator usage as "cheating," not really doing mathematics, or "taking the easy way out."

Given these concerns about calculator use in today's classrooms, however, keeping opportunities to learn the use of computing tools effectively and efficiently from students may put them at a distinct disadvantage in our highly technological society (Reys and Arbaugh, 2001). When one pairs this with the fact that calculator use in mathematics has been continuously endorsed by the NCTM (1986, 1989, 1998, 2000), it is all but certain that calculator use will likely play as prominent a role in tomorrow's classrooms as it does today.

Anxiety

Anxiety is to be expected in some form when a student approaches any field of scholastic endeavor, but can be overwhelmingly so when addressing the field of mathematics. Richardson and Suinn (1972) described math anxiety as "involving feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p.551). Buckley and Ribordy (1982) have defined math anxiety as an "inconceivable dread of mathematics that can interfere with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations" (p. 1).

Research by Jackson and Leffingwell (1999) suggests that only about 7% of Americans have had positive experiences with mathematics from kindergarten through college. Furthermore, Burns (1998) has estimated that up to two-thirds of American adults fear math. The most common cause to contribute to math anxiety is thought to be past negative experiences with mathematics (Tobias & Weissbrod, 1980). These past negative experiences with mathematics appear to form early in an individual's life, as illustrated in a study by Suinn, Taylor, and Edwards (1988). They created a mathematics anxiety rating scale for elementary school students and found that many elementary students suffer from mathematical anxiety. In addition to early negative influences, the formation of math anxiety may also be the result of a variety of other factors, such as an inability to handle frustration, excessive school absences, poor self-concept, parental and teacher attitudes toward mathematics, and emphasis on learning mathematics through drill without understanding (Norwood, 1994).

Calculator Anxiety and Technophobia

It is no great stretch to assume that a student would generalize math anxiety to math-related technology, such as calculators, and thus also experience math technology anxiety, or for the purposes of this study, calculator anxiety. Many studies have shown the link between math and anxiety (Betz, 1978; Hembree, 1990; Ho, H., Senturk, D., Lam, A. G., Zimmer, J. M., Hong, S., Okamoto, Y., Chiu, S., Nakazawa, Y., & Wang, C., 2000; Ma, 1999) but none have examined the relationship between math-related technology, such as graphing calculator usage, and anxiety so it is impossible to cite references here pertaining to the topic of anxiety caused by math-related technology.

However, studies have been conducted (Dalton & Hannafin, 1987; Gardner, Discenza, & Dukes, 1993) in the area of technophobia or fear of technology. These studies have found that technology in general can cause anxiety and therefore may be viewed as possible indicators as to how the anxiety of students may increase when faced with math-related or graphing calculator technology. Thus, for the purposes of this paper, terms such as technophobia (the fear of technology) and computer phobia will be viewed as interchangeable with calculator anxiety.

Technophobia can be an unintended consequence of the introduction of technology such as graphing calculators into a mathematics curriculum (Brosnan, 1998). This introduction of technology with graphing calculators could be even more detrimental for mathematics students because the anxiety already experienced by many students with mathematical concepts may be doubled due to difficulties with or fears of technology (Hembree, 1990). In other words, the technology of graphing calculators designed to make mathematical learning easier for all may in fact aid only those with an affinity for mathematics and positive attitudes towards technology. Furthermore, the introduction of technology in the form of graphing calculators into the mathematics classroom may overwhelm those who are already struggling with basic mathematical concepts and place them at a greater risk of failure.

Age and Gender Effects on Mathematical and Calculator Anxiety

Many factors are attributed to the causes of anxiety with technology. Age seems to have some influence in that the older an individual, the greater the anxiety or computer phobia (Brosnan, 1998; Connelly, 1994). Charness, Schumann and Boritz (1992) found that younger subjects performed better under all training conditions than older adults. Their study addressed the user friendliness of technology. Many older students reported the computers were not user friendly and complained of not being able to see graphics on the screen as readily as younger programmers. Anxiety was higher for older adults leading to negative attitudes toward technology and a lack of confidence in their abilities to learn.

However, more material has been written on gender factors in the fear of technology (technophobia) and mathematics performance than the previous factors. Historically, males have coped better with anxiety in general and specifically with computer anxiety (Gressard & Loyd, 1987). Research shows that this dominance occurs at an early age. Archer and MaCrea's (1991) study of 11-12 year-olds shows that certain school subjects were male or female oriented already at this young age. For example, they found that males were more mathematically oriented than females and females more English and literature oriented than males. This pattern of male versus female orientation was confirmed to continue into the academic career of young adults in their college aspirations (Frieze, Sales & Smith, 1991). Ethington and Wolfe (1986) reported that men on the average achieve higher scores in mathematics and these higher scores have been linked with increased male enrollment in secondary and tertiary computing courses (Clarke & Chambers, 1989).

Females seem to have a greater fear of technology, which has been demonstrated through lower scores on computerized tests. For example, a personality test, administered for businesses, rated women lower. It was later revealed that because the version of the test was computerized, it had more impact on the results than the test itself (Lankford, Bell & Ellias, 1994). Overall, it has become commonly accepted that males relate better to technology careers than females (Lightbody & Durndell, 1996). The lack of female enrollment in computer courses, less experience with computers, fewer female role models, and less encouragement from parents and teachers have been blamed as possible causes for lower female participation in technology careers (Clarke & Chambers, 1989).

In the secondary school setting, Shashaani (1994) showed that gender differences in computer experience had a direct relationship to computer attitudes. Males generally had more computer proficiency, which is directly related to usage, access, and number of computer classes attended. Other researchers attributed the difference to social role expectations and experience (Colley, Gale & Harris, 1994; Brosnan, 1998). When these attributes were eliminated from their study, no significant gender differences remained. Boaler (1997) showed that females are trying to combat the illusion of male superiority in mathematics and technological areas. One method that Boaler suggested was that classes be more open group-oriented and project based.

Performance and Anxiety

The link between mathematical anxiety and performance has been established in the literature. For example, Hembree (1990) conducted studies in elementary, secondary, and college mathematics classrooms and found evidence of correlations between mathematics anxiety and poor mathematics performance He concluded: "Mathematics anxiety seriously constrains performance in mathematical tasks and that reduction in anxiety is consistently associated with improvement in achievement" (1990, p. 522).

A few researchers have examined the effect of computer and technological anxiety on performance (Griswold, 1984; Vogel, 1994). Griswold (1984) studied computer anxiety and performance in students and discovered the more anxiety students encountered, the more their performance suffered. Griswold dubbed this the negative linear theory, meaning if anxiety is at a high level, performance is anticipated to decrease. Simply put, the greater anxiety the greater the loss of ability.

Contrary to this theory, Vogel (1994) noticed that under certain conditions some individual's performance was enhanced when they experienced intense rates of anxiety for brief periods of time. His theory suggests anxiety may actually increase student performance by heightening awareness. The student becomes more attuned to keeping commitments and increasing achievement although the anxiety increases. The performance increases proportionally to the amount of anxiety experienced. This theory is known as the arousal theory (positive linear theory) because although the student may experience increased anxiety, they become catalyzed through the anxiety to perform better than if they experienced reduced anxiety (Bush, 1991; Vogel, 1988). The contradicting aspect of this theory to negative linear theory is that in arousal theory some individuals actually flourish with the mounting pressure to succeed. It is as if they are energized by the demand of time restraints by having a deadline to complete an assignment. It is important to note here, however, that there seems to be an individual threshold for anxiety tolerance and increased performance. Too much anxiety will always cause decreased performance, although "too much" is entirely subjective to the individual.

Instruments such as the Mathematics Anxiety Rating Scale (MARS) by Richardson and Suinn (1972), Mathematics Anxiety Scale (MAS) by Fennema and Sherman (1979), and Mathematics Anxiety Questionnaire (MAQ) by Wigfield and Meece (1988) have been developed to measure the level of mathematical anxiety a student may feel when faced with assignments or tests. Kazelskis (1998) performed a factor analysis of these instruments and provided six factors he found to be the most important when assessing mathematical anxiety:

1) Mathematical Test Anxiety: although the student may understand mathematical concepts during normal coursework, he or she is unable to apply these concepts during mathematical testing because of overwhelming mathematical test anxiety.

2) Numerical Anxiety: the student experiences anxiety when dealing with mathematical numbers and derivatives of number groups such as fractions, rational, irrational, complex, and imaginary numbers.
3) Negative Affect Toward Mathematics: the student simply does not "like" mathematics and therefore experiences frustration in dealing with mathematical functions, concepts, and terminology.
4) Worry: General worry or anxiety that may or may not be math related but does affect math performance in the classroom.
5) Positive Affect Toward Mathematics: the student possesses an inherent "like" or affinity for mathematics and will therefore view mathematical difficulties as positive challenges rather than frustrations.
6) Math Course Anxiety: anxiety elicited simply by enrolling in or attending a mathematics course.

Theorists and educators as indicators can use these factors to the type (if any) of mathematical anxiety a student will experience. Furthermore, the mathematical anxiety level elucidated by these factors can be valuable in determining whether a student has negative-linear or arousal type mathematical anxiety.

Coping

Many people feel stress or anxiety in their lives. How individuals reconcile this stress determines whether they are successful in their endeavors. The way people handle stress is called coping (Lazarus, 1993). Folkman and Lazarus (1988) describe coping as the "efficacy to the quality of the fit between coping strategy, its execution, and the adaptive requirement of its encounters" (p. 240). Lazarus defines coping "as ongoing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the recourses of the person" (1993, p. 284). Folkman and Lazarus (1988) have classified the two dominant categories of coping into flight vs. fight. Although, for convenience, I categorized coping into flight versus fight, Fokman and Lazarus actually divides coping into eight levels. Their levels of coping were confrontive coping, distancing, self-controlling, seeking social support, accepting responsibility, escape-avoidance, planful problem solving and positive reappraisal. Lazarus (1993) later reclassified flight vs. fight into avoidance-denial vs. attentive-confrontational styles of coping. He approaches coping as either a style or as a process. Style can take the form of either regression, meaning avoidance or denial, or sensitization, meaning confrontation or vigilance. Style can be beneficial or harmful depending on the situation. Avoidance or denial can lead to levels of apprehension and be counterproductive, but can also lead to thorough and complete work after the student have taken time to reflect on the assignment. A negative example of avoidant coping would be a student taking any measure to keep from doing or delaying completion of the assignment. A positive example of avoidant coping may be a student taking time for reflective thought where the individual does not make harried decisions. Sensitization or vigilant coping may lead to effective efforts to combat anxiety, but also may lead to rash, undesirable efforts. A negative example of vigilant coping would be a student making a hurried job of the assignment without close attention to detail. A positive example of vigilant coping may be that the student will always find a way to finish the assignment and will tend to persevere, regardless of the difficulty. The process used by the individual determines the style that is incorporated into their way of coping.

Instruments have been developed to measure coping strategies of students who experience mathematical anxiety. Schwartzer and Schwartzer (1996) prepared a survey to measure the effectiveness of coping instruments. They state that the main conceptual issues of coping are stability, generality, and dimensionality.

1) Stability: is simply the pattern similarity of individual differences at different points of time. For example, one can assess whether a person is always applying the same set of strategies in a situation or is broad range of tactics are used in changing encounters. Compounding this concept is that stability is difficult to maintain when a crucial issue has stages, which require different actions at each stage.
2) Generality: is the classification of coping responses in a unique situation. Would a person generate the same type of response to different trying situations? The measurement of coping can only be beneficial under the assumption that individuals generalize across situations to a certain degree and come up with a limited set of strategies at different occasions.
3) Dimensionality: is how the sets of strategies can be grouped. The two basic dimensions used by most researchers are variations of the attentive, vigilant, confrontive or fight coping compared to the avoidant, passive, escape mode used to explain the flight style of coping.

Many scales are used to measure coping. However, Folkman's and Lazarus's (1988) Ways of Coping Questionnaire used an inventory scale which classifies the two main categories as the fight versus flight scenario and seemed to fit best with the goals of this paper.

Summary

The purpose of this study is to explore the relationship between anxiety, coping and success in mathematics classrooms using graphing calculators. Literature that pertains to these areas of exploration has been discussed at length. The advantages of calculators were discussed. Mathematics anxiety and calculator anxiety, age and gender differences in math anxiety and technophobia, and the effect of anxiety on mathematics performance were also covered. Finally, the two major coping strategies, attentive-confrontational and escape-avoidance were presented to explain the ability of persons coping with calculator anxiety.

CHAPTER III

Methodology

The purpose of this study was to identify the effect of mathematical anxiety, calculator anxiety, and coping style on student success in mathematics classrooms. This will lead to an understanding of how the phenomenon of anxiety with calculators and mathematics paired with coping style correlates with their mathematics grade.

Because the purpose of the study was to generalize from a sample community composed of American military personnel, dependents of the American military or American civilians working in the United Kingdom, a survey was preferred because of economy, rapid turn around and the ability to identify attributes of a population from a small group of individuals. The survey was cross-sectional meaning that it was given to all mathematical students in the classes surveyed. The data was collected during the winter term of 2002/ 2003-school years. The survey was administered in a face-to-face format at the beginning of a class session. The instructor of each class approved this arrangement, which was considered the quickest, most convenient and least invasive for both the instructor and the students.

The independent variable in the study was students' self-reported mathematics grades. These grades could not be checked for accuracy since the questionnaire was voluntary and anonymous. The dependent variables included students' mathematical anxiety, calculator anxiety, and coping style. The speculation was that a student's mathematics grade would be dependent on the anxiety they encounter with mathematics, the anxiety they experience through the use of calculators, and the strategy they used to deal with this anxiety.

Participants

After permission was granted from the Institutional Review Board (IRB) at Oklahoma State University to use a survey for data collection, permission was sought from the site university of the students I surveyed for the study. At the site university, I obtained permission from a representative of the school to allow for eventual selection of students for the study. The representative was the go-between the researcher and the university and secured the permission for each class to be surveyed. The university representative coordinated the times the researcher could survey the classes.

There were 76 participants in this study. Divided by gender there were male (56%) and female (44%) undergraduate college students from mathematics classes at an extension campus at an American university located on an American military installation in England. 94% of the students in the survey were U.S. citizens, 4% were British citizens, and 2% were citizens of the Philippines. The oldest student surveyed was 41. The youngest was 19 years. A mean age for the classes came 26. The standard deviation for the group was 5.965. Sixty-two percent (62%) of the students surveyed were white, 17% were African-American, 14% were Hispanic, 5% were Asian, and 2% were Pacific Islanders. The majority of the participants were military personnel or military dependents that were going to school on a part-time basis. The participants were students in seven mathematics classes consisting of two introductory remedial courses not for credit, three intermediate courses and two advanced courses for credit. This provided participants ranging from beginning students with very little mathematical experience, to students with higher levels of mathematical experience. The participants in this study consisted of individuals who were attending class on the day the study instrument was administered and agreed to participate in the study. Out of 77 students in the seven classes surveyed, only one student declined to participate in the study.

Instrumentation

Development of the survey instrument used in this study combined two individual inventories. The first part of the instrument was based on Kazelskis' (1998) *Some Dimensions of Mathematics Anxiety: A Factor Analysis Across Instruments*. Kazelskis developed his survey from the Mathematics Anxiety Rating Scale (MARS) by Richardson and Suinn (1972), Mathematics Anxiety Scale (MAS) by Fennema and Sherman (1979), and Mathematics Anxiety Questionnaire (MAQ) by Wigfield and Meece (1988).

The second part of the survey instrument was an adaptation from Folkman and Lazarus' (1988) *Ways of Coping Questionnaire*. The questionnaire established coping strategies (attentive-confrontational, fight, or escape-avoidance, flight) the students used when faced with mathematical anxiety and/or calculator anxiety. The Folkman and Lazarus questionnaire in conjunction with the Kazelskis' anxiety survey were used together to first ascertain the amount of mathematical and graphing calculator anxiety a person displayed and then the strategy used to cope with the anxiety. Both of the instruments were adapted for use in this study was found to be both reliable and valid by the original authors (Folkman & Lazarus, 1988; Kazelskis, 1998).

There were 72 total items in five subscales (listed below) on the survey used during this study. The first four subscales established anxiety levels as pertaining to mathematics and graphing calculator use and the fifth subscale measured the coping style the respondent used to deal with mathematical and graphing calculator anxiety. The subscales were 1) How do you use calculators, 2) Do you worry, 3) What is your math confidence, 4) What is your anxiety level when, and 5) In a stressful situation. Responses to the first four subscales were arranged on a five-point Likert scale ranging from "not at all," "not very much," "a little," "much," to "very much." Responses to the fifth subscale "In a stressful situation" were also arranged on a five-point Likert scale, and ranged from "not used," "used somewhat," "used a little," "used quite a bit," and "used a great deal."

Each item on the first four subscales was given a score from one to five; one being low mathematical or graphing calculator anxiety, and five being high mathematical or graphing calculator anxiety. Some items were reverse ordered in order to prevent respondents from confounding the instrument by answering all of the items in a rote fashion. The items on the fifth subscale were given a score from one to five to determine the respondent's coping style when faced with mathematical and graphing calculator anxiety. A low score, such as one or two, meant that the respondent was utilizing an escape-avoidance coping strategy, while a high score, such as a four or five meant that the respondent used attentive-confrontive coping strategy. A score of three meant that the respondent utilized aspects of both escape-avoidance and attentive-confrontational coping strategies.

Data Analysis

The purpose of this study, then, was to explore the coping techniques of students and their success. In mathematics classrooms using graphing calculators, the following will be done:

1. Document student perceptions about how they cope with mathematics and technology, and document their success.
2. Analyze these perceptions of coping through the lens of escape-avoidance or confrontational coping theory (Folkman & Lazarus, 1988).
3. Document other realities revealed.
4. Assess the usefulness of escape-avoidance or attentive-confrontational lens of coping for understanding the phenomenon under study (Folkman & Lazarus 1988).

Analyses of the survey data were conducted using the Minitab program and the statistical information is presented in Chapter Four.

CHAPTER IV

Presentation and Analyses of Data

The Minitab program used statistical measures to analysis the data, which include multi-variable linear regression, Pearson's correlation, best subsets regression, analysis of variance, and analysis of residuals from the prediction model. The cross-correlations between the six prediction measures are given in Table 1 below.

Table 1

Pearson's Correlation and p-value

	Calculator Stress	Worry	Math Anxiety	General Anxiety	Attentive-Confront.	Escape-Avoidance
Worry	-0.086					
	0.458					
Math	0.110	0.540				
Anxiety	0.342	0.000*				
General	0.014	0.562	0.702			
Anxiety	0.903	0.000*	0.000*			
Attentive-	0.003	0.336	0.442	0.514		
Confront.	0.978	0.003*	0.000*	0.000*		
Escape-	-0.055	0.236	0.362	0.454	0.712	
Avoidance	0.639	0.041*	0.001*	0.000*	0.000*	
Grade	-0.328	-0.286	-0.438	-0.383	-0.413	-0.330
	0.004*	0.012*	0.000*	0.001*	0.000*	0.004*

* Significant at .05

The six predictors are calculator stress, worry, math anxiety, general anxiety, attentive-confrontational coping strategy and escape-avoidance coping strategy Table 1 is a correlation between these six factors with each other, compared two at a time. The top value in each box is Pearson's correlation of the given values. The bottom value is the probability relationship between the two factors. The values of $p < .05$ show statistical significance and indicate they would not happen by chance. Since attentive confrontation and escape avoidance are both negative as on Table 1, the theoretical explanation must be that when students learn to use the technology, their grades improve and their coping reduces because they are acting automatically.

The predicted grade, the independent variable, is the last value in the table. All the values are negative which corresponds to the negative linear theory hypothesis. It also supports the positive negative linear theory hypothesis associated with arousal theory. Pearson's correlation ranges from –0.286 to –0.438 and the p-values are from 0.000 to 0. 012.

Best Subsets Regression

Because some of the variables were highly correlated, escape-avoidance and attentive-confrontational as the highest for example, it was decided to reduce the number of variables for the prediction model. An analysis of the Best Subsets Regression by Minitab as given below (See Table 2) shows that an R^2 of 33.9% could be achieved with only three variables. In this Best Subsets method used by Mini-Tab, the subsets are determined by Best subsets regression using the maximum R^2 criterion. Best subsets regression generates regression models using the maximum R^2 criterion by first examining all one-predictor regression models and then selecting the two models giving the highest R^2. The Mini-Tab program displays information on these models, examines all two-predictor models, selects the two models with the highest R^2, and displays information on these two models. This process continues until the model contains all predictors. This is different from stepwise regression, which is based on the F statistic. The stepwise regression eliminates certain variables and does not examine all the predictors as the process proceeds.

Using the three variables, Calculator Stress, Math Anxiety and Attentive-Confrontational score gives the best regression for a reasonable number of variables and no significant improvement in the prediction model could be achieved by adding additional predictors. This value is labeled as 3-A Vars. The table suggests that almost 34% of the grade variation might be predicted by looking at these three personality variables, in bold below.

Table 2

Best Subsets Regression with Calculator stress, Math Anxiety, Attentive-Confrontational Coping

R Squared Value	33.9
Adjusted R. Squared Value	31.1
Candidate Predictor Value	2.1
SD	.747

The first row in the table indicates the number of prediction variables used in the model. The variables used in each model are indicated with X's in the column. Note that although the two strongest single variable predictors were math anxiety and attentive-confrontive, their correlation made them less useful when combined in a two variable prediction model than the combination of calculator stress and attentive-confrontational variables. Instead of selecting the entire possible outcomes, the researcher decided to pick only the top two subsets, labeled A and B from ascending number of variables starting from one. The last number, six, has one possibility since all the variables are used to predict the outcome of grades. The variables (Vars 3-A) in the table (bold) are the best predictor of grades. These three are calculator stress, mathematical anxiety and attentive-confrontational variables. They display the best results with the highest value of R^2, for a three-variable model.

The R^2 value is an indication of the strength of the prediction model. The adjusted value is when some corrections in the program are automatically completed to allow for some distortion of data, like outliners. Although the R^2 value of 33.9 is not the highest, the value does not significantly improve when four, five and all six variables are used. The sum of the squares or the difference between the observed values and the mean values of a variable is called the total sum of squares. It is usually divided into two parts; the part, which can be traced to the prediction variables, called the sum of squares of the regression, and the part, which is not explained, by any of the prediction variables, usually called the sum of the squares for error. The statistic R^2 is the ratio of the sum of the squares for regression divided by the total sum of the squares. It can be thought of as a measure of the strength of the prediction model, with an R^2 of one indicating a perfect prediction model, which predicts every grade.

The results of my model gives R^2 =19.2 for the best one variable linear model. The addition of a second variable raises the R^2 value to 27.7, and with three variables the

R^2 increased to 33.9. Beyond three variables there were no significant increase in the R^2 value, reaching only 34.9 using all six measured variables.

The next value in the table, C-p, is a statistic developed by Mallow at Bell Laboratories as a metric for evaluating candidate hierarchical models. This situation arises in multiple regression models where you have one response and several predictors. In my model, the response is the computerized grade with the best subset contained in Vars 3-A. In statistics, if the C-p value is small and also close to the p value, then the expected value of C-p is approximately equal to p, the number of parameters in the model. A small value of C-p indicates the model is relatively precise in estimating the true regression coefficients and predicting future responses. This precision will not improve much by adding more predictors. Models with considerable lack of fit have C-p values larger than p. In comparison with this table, column Vars 3-A gives the highest R^2 value of 33.9% for a subset of three parameters and the lowest C-p value of 2.1. This value is small, under the number of three parameters, precise, and a good predictor for validation and reliance in the tables.

The equation for this model is computed this way: C-p = (SSEp / MSEm) – (n-2p) where SSEp is SSE for the best model with p parameters. The MSEm is the mean square error for the model with all m predictors.

The Prediction Model

The purpose of the research was to correlate the amount of anxiety a person displayed with the strategy they used to cope with this anxiety. The questionnaire used in the survey would be validated and stated as reliable if the process was capable of predicting a student's grade. On the questionnaire, the participants were asked to self-report their mathematical grade. Using the Minitab program, the researcher was able to predict the computerized grade for individuals using the regression model. The model based on the formula, Grade = 6.04 - 0.046*(calculator stress) -0.024*(mathematical anxiety) -0.035*(attentive-confrontational). For the purpose of this study, calculator stress, math anxiety, and attentive-confrontational variables were used, as they were the highest predictor of grades. The standard deviation for these three variables is 0.74657, the R-Square is 33.9%, and the adjusted R-Square is 31.1%. The actual details of the regression study are shown in Table 3.

Table 3

The Predictor Model

Predictor	Coefficient	S D	T-Test	Probability
Constant	6.039	0.547	11.03	0.000
Calculator Stress	-0.046	0.017	-3.07	0.003
Math Anxiety	-0.025	0.009	-2.58	0.012
Attentive Confrontational	-0.035	0.013	-2.70	0.009

The coefficient for the predictor model is the constant equivalent to the grade beginning at 6.039 and decreasing by the coefficient multiplied by the number of times a student indicates calculation stress, math anxiety, or attentive-confrontational coping behavior. The second column indicates the standard deviation for grade and the three predicted values. The T-test is the test of significance and all are significant at their different ranges. The probability of 0.000 as a constant shows it is not likely to have happened by chance.

Analysis of Variance

The variance is related to the difference between the observed grade and the predicted grade by the model. This variance of a set of data is measured by taking the mean of the squares of the deviations from the mean of the sample. Table 4 reports this data.

Table 4

Analysis of Variance (ANOVA) Between the Observed Grade and the Predicted Grade

Source	Degree of Freedom	Sum of S D	Sum Means	Frequency	Probability
Regression	3	20.541	6.847	12.28	0.000
Residual error	72	40.130	0.557		
Total	75	60.671			

The number of total degrees of freedom is the number of subjects less one; 76-1 = 75. Of these three degrees of freedom account for the estimations of the coefficients of each prediction variable, leaving 72 degrees of freedom for the error (residual). The P-value is rounded to zero (but could never actually equal zero) and indicates that it would be very unusual to get an association this strong by chance alone.

Table 5 explains the make-up of the sum of standard deviation for the three degrees of freedom. The values of 6.542, 9.932, and 4.067 for calculator stress, math anxiety and confrontational coping strategy add up to the 20.541 reported in Table 4.

Table 5

Individual Factors for Degrees of Freedom

Source	Degrees of Freedom	Sequential Sum of S D
Calculator Stress	1	6.542
Math Anxiety	1	9.932
Confrontational	1	4.067

The variance is also measured by the C-p value. It incorporates a measure of model variance and degrees of freedom. Cp = p + (n-p) (MSE (p) – MSE (t))/ MSE (t). In the model, P is the number of parameters; MSE (p) is the mean sum of squares for the candidate model with p parameters. MSE is the mean sum of squares for the full model, were t represents the total number of parameters. For predictive models, the rule is to use the first model where C-p is less than the parameters. In the data collected in Table 2, the C-p value was 2.1, which is less than the three parameters used.

Several observations about the study suggest that the model may be a very accurate predictor. The gradients of all the three variables in Table 1 had p values below 2% indicating a very strong statistical result.

The residuals plots (the two plots below, Figures 1 and 2) showed that the distribution of residuals was homeoscedastic and approximately normal with no pattern to suggest a lack of linearity in the model. The following three figures test the character of the distribution of the residuals. We recognize that there will be error in the model, but hope to avoid systematic error so that the residuals should essentially be normally distributed. The chart of residuals (Figure 1) shows the residuals by case number, allowing us to be assured that there is no pattern to the distribution over time or case. Figure 1 residuals displays all the values to be evenly distributed confirming the linear theory. A clumping of residuals at either end or in the middle of the chart would indicate other possible models.

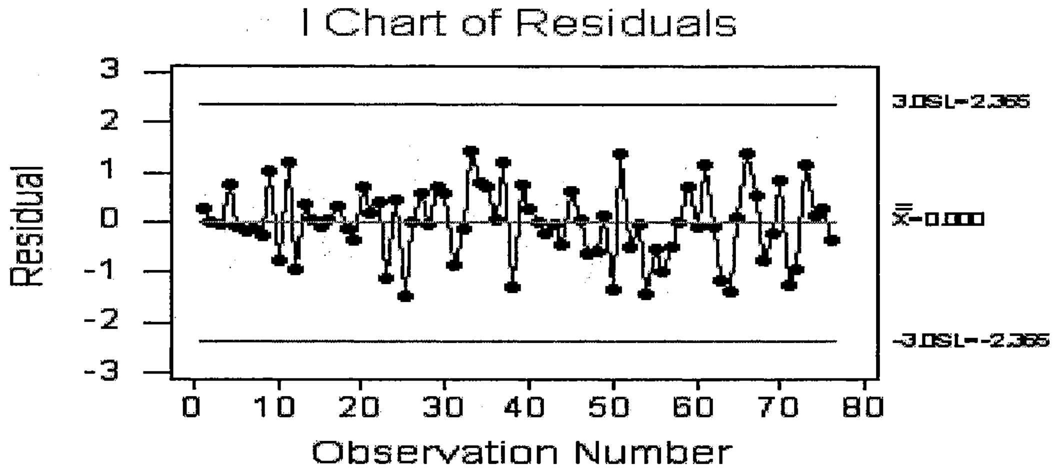

Figure 1. The Chart of Residuals

The histogram (see Figure 2) bears out that the distribution is essentially bell-shaped and symmetric, as they must be for the prediction to be reliable, and the normal quartile plot plots the residuals against their normalized z-scores to test a third way for approximate normality. A normal distribution makes a straight line on the normal quantile plot.

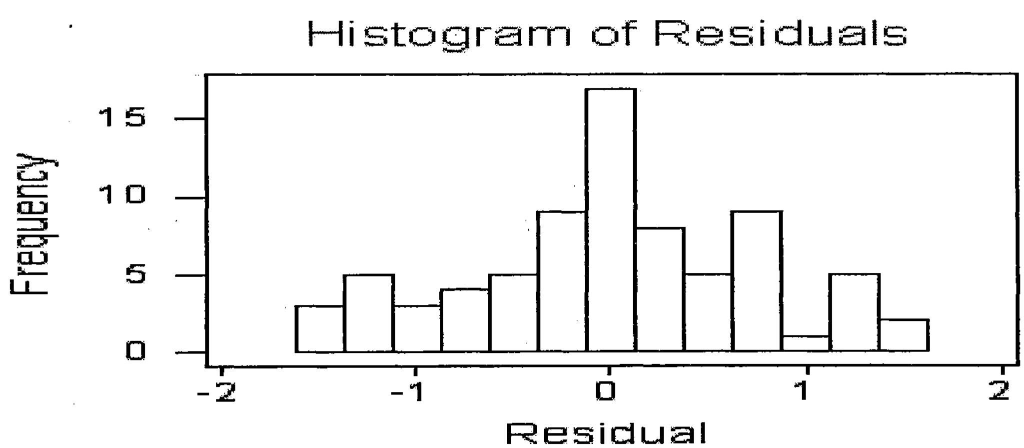

Figure 2. Histogram of residuals supports the linear regression model because of its bell-shaped symmetry.

Summary of Regression

To summarize, the instrument shows relatively strong internal consistency and reliability as measured by Cronbach's alpha test. Using the raw data the alpha scale reliability estimate was .76 with a 95% lower confidence limit of .68.

The residuals seem to be homeoscedastic, normally distributed, and show no pattern. This indicates that the linear model is probably the best model. To further assure myself that there were no underlying non-linear patterns, several methods were tried. To investigate that some combination of second order equations might have a better fit I combined squares of variables and products of variables to see if the resulting fit would be better than the present linear model. This data is shown in the Appendix C. For example, the first test checked to see if a model involving any combination of the square of the variable for Calculator stress, the Square of the variable for Math Anxiety, and the product of Calculator Stress and Math Anxiety would fit as well, or better, than the present linear model.

This was repeated with several variations of squares and products and even some cubic relations to see if I might find some permutation of them that might exceed the original model. With such interrelationships we could approach an adjusted R^2 of around 30%, but in each case the number of values with large standardized residuals indicated that the model was not a good fit for all the data.

Bootstrapping

Bootstrapping is a process in which information about a population is extended by taking repeated random samples from a sample, or sub-population, of the focus population. In this example, repeated samples of size 50, with replacement, were drawn from the 76 items in the sample. Each sample was treated as raw data and the adjusted R-square of the prediction model was collected. The program was run 20 times to find a potential Range of adjusted R-square values as a way of assessing the reliability of the model. The highest value was an R^2 index of 51 percent and a low of 15 percent. Compared with the 33 percent from the best subsets regression analysis, the bootstrapping process will predict a possible interval of outcomes if the survey is administered to a new sample. This provides for increased reliability, which would also increase the repricabilty factor for computer predicted grades. All 20 results of the bootstrapping regression analyses are displayed in the appendix.

The 20 adjusted R^2 values from the twenty regressions of samples of size fifty from the original seem to be approximately normally distributed on the basis of the Normal Quantile plot shown below (see Figure 3).

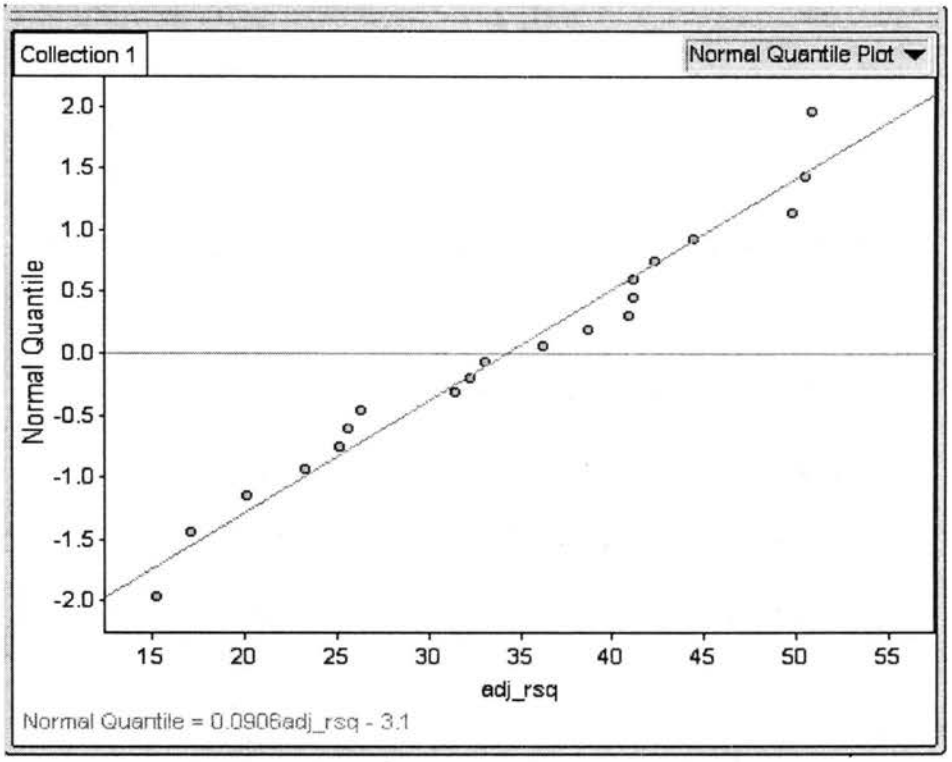

Figure 3. Normal Quantile plot.

The Normal Quantile Plot displays the 20 plots obtained by bootstrapping. The plot displays a linear regression normally distributed. Since the R^2 values seem to be approximately normally distributed and the t-distribution is very robust, a 95% confidence interval was used to predict the potential validity of the regression of grade against the three characteristic variable scores. The results of the test (Fathom® output shown below) suggest that we may estimate that if samples of size 50 were taken from an equivalent population, 95% of these tests would show an adjusted R-square in the range of 29% to 39.5%. The results of the present test at the low end of this range may be attributable to the fact that two of the classes had very low predictive value for this test, and an independent R-sq of essentially zero. Why this group seemed so atypical of the others and effectively lowered the overall strength of the prediction model is a worthy subject for a follow-up study.

Summary

Chapter IV is concerned with the presentation and analyses of data. Table 1 displays how the six factors correlate with each other by using Pearson's correlation. The probability of any of theses correlations happening by chance is almost nil with each factor correlated to the students' self reported grade exhibiting significant at .012 and lower. The best subsets regression Table 2 gives us the best predictor of grades with an R^2 value of 33.9, adjusted R^2 value of 31.1, C-p value of 2.1 and standard deviation of .747. The prediction model, illustrated with Table 3 uses the same factors as in Table 2 and accurately predicts the performance of all the participants in the study except for two outlines in Table 6. Table 4 displays the amount of variance for the whole model, while Table 5 gives the values of variance the three factors uses as predictors. Finally the Histogram of Residuals and the Chart of Residuals proved a linear regression model exist as does the 20 bootstrapping trials (see Figures 1 and 2). They all confirm the data in the original pilot study.

What can be concluded is that some students have calculator stress in combination with mathematical anxiety. This anxiety can be in the form of negative linear performance stress or robust performance stress. The negative linear performance stress anxiety was the most common anxiety form exhibited by the participants.

The style of coping best used by students was the attentive-confrontational style. The style of coping chosen by the student depended on the student's own personality and which style caused less anxiety. It is concluded that after students learned how to use the calculator, automization occurred, and their mathematical performance increased.

Meaning, that since students could give full attention to the problem and not to the anxiety caused by calculator stress, they generally would perform better. This leads to the theoretical procedure, that reducing anxiety by first teaching the technology would allow students to apply it in practical applications.

When calculator skills are deficient, the increase in mathematical anxiety causes increased stress and weakens performance. Since the attentive-confrontational behavior was the best performance enhancing coping device, the student is pro-active in determining their own destiny on how well they will perform in a mathematics class. The escape-avoidance coping behavior seems to allow the anxieties to control the student.

CHAPTER V

Summary of the Study, Conclusions, Implications, and Discussion

The conclusions, implications, and discussion have been drawn from careful examination of the data. The dialogue between members of my committee and myself helped in the interpretation of the data as given in the report.

Study Design

The purpose of this study was to identify the relationship between anxiety, coping and success specifically, in mathematics classrooms using graphing calculators. The method chosen to research this problem was by the use of a questionnaire. Using an instrument originally designed for use on a mathematical anxiety by Kazelskis (1998); the researcher modified the first 50 questions on the survey to include graphing calculators. The second part of the study consisted of 22 questions from a modified questionnaire developed to identify coping strategies by authors Folkman and Lazarus (1988). The participants filled in both sets of questions at the same sitting for anxiety identification and then responded to the type of coping strategy employed as well as providing their self-reported grade.

Based on the results of the survey, I documented student perceptions about how they (a) cope with mathematics, (b) cope with technology, and (c) self-report their success. I analyzed these perceptions of coping through the lenses of escape-avoidance or attentive-confrontational coping theory (Folkman & Lazarus, 1988) and documented the coping strategies used and assessed escape-avoidance or attentive-confrontational coping mechanisms. This lead to an understanding of how the phenomenon of anxiety with technology and mathematics correlates with their mathematics grade using graphing calculators.

Conclusions

The conclusions of the study identify the negative linear anxiety concept as the predominant theory. In every case and every scenario, each possible combination generated a negative slope.

The type of anxiety combined with strategies for coping in the survey analyses compared the predicted student's grade with their self-reported grade. The coping strategies were either attentive-confrontational or escape-avoidance. The regression analysis from the Minitab® program (McKenzie, Schaefer & Farber, 1995) correlated the data and produced the following results. The combination of factors with the greatest significance was calculator stress (-0.046), math anxiety (-.0238) and attentive-confrontational coping strategy (-0.033) for a combined prediction of 33.9% for computerized grades. Bootstrapping allowed this percentage for predicting grades to increase to 51%. Automization occurs after the student learned how to use the calculator and the coping style would not necessarily be a factor in the model.

Observations and Speculations

My observations and speculations contain insights gleamed from this study on the prevailing theories, research, and practice currently being done with technology and graphing calculators. The predominant theory observed was the negative linear theory, before automization was taken into account. This theory conformed to the data and the parameters set in the questionnaire. Observing research methods were long and laborious. I had to find the right instrument for calculating anxiety and another for defining coping. Observations in practice have been ongoing for the last 25 years in my experience as a mathematics teacher. I am now better armed with solutions when students are suffering from anxiety with technology.

Theory

The negative linear theory was the only theory to be displayed by the data. For future applications, different questions could be devised that covers different aspects of technology and not just graphing calculators. The conclusion researchers would want to find out is if the negative linear theory or high anxiety and low performance would be the dominant theory in revised studies.

The second part of the questionnaire was that the attentive-confrontational was the desired method for students to use as a strategy for combating anxiety. Researchers would design surveys to determine if attentive-confrontational would still be preferred over the escape-avoidance strategies of coping with anxiety.

The negative linear theory and the arousal robust theories were the most common anxiety theories in the literature. Some authors may have used slightly different terminology, but the type of theory remained essentially the same.

I found that the negative linear theory to be the best predictor of grades when coupled with mathematical and calculator anxiety. The arousal anxiety theory explains why students might do well for a short period of time, but as the anxiety increases to a point they could not tolerate, performance would decrease.

Research

The implications for research are numerous. Several important observations and questions emerge. A major question for future research could be the possibility of affecting grades by altering the student's way of dealing with calculator anxiety. In calculator stress, for example, researchers can alter the index or counseling in such a way that it would influence grades. An experimental format could be adapted to conduct a new study. A control group would be necessary as a check to solve mathematical situations as they had in the past. Teaching the selected experimental group ways to handle stress is a problem that comes with working mathematical problems and using the calculators for their solutions. Monitoring the participants in ways to handle different mathematical calculator situations would be essential for explanation and evaluation. Other self-assessed characteristics chosen for their impact on education will have to be developed. This addition or deletion would develop the characteristics that best serve the students.

The study has added to the body of knowledge for research. Some implications would be the study of different students at all levels of schooling including elementary, secondary and college. The researcher for comparison studies could investigate the type of calculator used. The courses the student is enrolled in and the type of previous training with calculators the student had before the questionnaire was given, could be a factor. Since all of the students were either active military, their dependents, or associated with the department of defense, another population without this strict discipline background could be a factor as to what would needed to be altered for another generation to take the questionnaire.

Practice

Under the speculation of practice, I think that once a student's type of anxiety is assessed, then it would be possible for an instructor to recommend the best coping strategy. This could be confirmed by diagnostic tests, which would indicate the preferred coping style that enhances the student's performance.

Mathematics education would be changed because now an instructor would know what type of anxiety to expect from students taking math courses. With knowledge, the instructor has a better idea of what the students are stressing about and what coping mechanisms would best alleviate these stresses.

Recommendations

The recommendations are my own after concluding the study. More research needs to be initiated that will affirm the data or show areas were information is lacking. The recommendations are in the field of theory, research, and practice.

Theory

All persons do not exhibit the same behavior under similar anxieties at different times. Using the arousal robust theory as an example, I think more research should be undertaken to determine at what point a student's performance would decline. It seems to be a very low threshold for most students, but some excel with the added anxiety. When this demarcation line is reached, then the coping style could be changed to accommodate how the student has changed their perception of the anxiety. This changing of coping style would maximize student efforts with performance. Automization draws attention to the fact that as the technology is learned sufficiency, then coping skills are not required as much if the technology is not learned.

Research

To find this point of demarcation, it might be as simple as observing the student to determine when they are becoming frustrated. However, I think more sophisticated research in the area of electro-chemical changes in a person's body that may elucidate a physiological indicator to an individual's anxiety or frustration threshold. A sensor could be developed to let the student know when their level of anxiety has been reached and they will need to lower the anxiety level if they want to be successful with this time interval. If such devices were found to be practical, students would know the best time and how much effort to put in their studies. The all night cramming for a test may be more non-productive then just taking it easy and getting a good night's rest. The results could be staggering and overwhelming for the student's frame of mind of when to work with how much pressure.

Practice

Ways to change or alter practice so that student's grades improve should be the final objective for future practice. Student's grades would improve as a result of the best practices determined by the data. Higher grades would be the natural result of the implications that the practice would have on future students. Lowering anxiety by attentive-confrontational is a method to alleviate the stress to maximize performance. Teacher training enhancement classes for stress management would be a natural outcome for improvement of grades. Prerequisite classes in calculator usage might be necessary for students to perform with calculator usage in areas the students are not prepared to investigate. Since a military community was used, it could be determined if the practice recommendations would hold up in alternative venues.

Commentary

This study has been very insightful for me. I did not know how to do original research or the format it should take. I have increased my knowledge of statistics, anxiety, and coping styles that will benefit as I try to incorporate these finding into my teaching.

I have learned how the types of anxiety can be debilitating to so many people. The causes of stress vary from individual to individual which makes the production of a questionnaire so difficult to reproduce. How persons cope with this anxiety is just as difficult to document. These two ingredients are not only necessary, but essential if grasps of the whole question how to succeed is explored.

I have learned why I am able to cope at times and feel exhilarated and continued to push when I had a very difficult assignment but thought the end was near. I also know why I would delay or avoid it as long as possible if I was feeling down or otherwise indisposed to completing the assignment.

The survey was straightforward and gave exact book guidelines results. These results may be a result of the military character of the participants. Department of Defense personnel have developed a very orderly, precise method of living their lives as a sub-culture to the general population. They approach a situation as in unison and deal with in a concerted manner. When all the results endorsed the negative-linear theory without exception of low anxiety and high performance, I thought of some common thread for this reaction. If this is the solution, then a new study to develop various population strings may be necessary.

REFERENCES

Archer, J. & Macrae, M. (1991). Gender perceptions of school subjects among 10-11 year olds. *British Journal of Educational Psychology,* 61, 99-103.

Ball, S. (1994). *Programs for the TI-81 and TI-82 Calculators.* Sunnyvale: Stokes Publishing Co.

Bandura, A., Cioffi, D., Taylor, B., & Broillard, M. (1988). Perceived self efficacy in coping with cognitive stressors and opioid activation, *Journal of Personality and Social Psychology, 55*(3), 479-488.

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology, 25*, 441-448.

Boaler, J. (1997). Reclaiming school mathematics: the girls fight back. *Correspondence*, 285-304.

Brace C. & Brace, C. (1995). *Understanding statistics*. Lexington: D.C. Heath and Company.

Brosnan, M. (1998). *Technophobia: The psychological impact of information technology.* London: Routledge.

Buckley, P. A. & Ribordy, S. C. (1982, May). *Mathematics anxiety and the effects of evaluative instructions on math performance.* Paper presented at the Midwestern Psychological Association, Minneapolis, MN.

Burns, M. (1998). *Math: Facing an American Phobia*. Sausalito, CA: Math Solutions Publications.

Bush, W. S. (1991). Factors related to changes in elementary students' mathematics anxiety. *Focus on Learning Problems in Mathematics, 13*(2), 33-43.

Carlson, R. & Wright, D., (1993). Computer anxiety and communication apprehension: Relationship and introductory college course effects, *Journal of Educational Computing Research, 9*(3), 329-338.

Carpenter, T. P., Corbitt, M. K., Kepner, H. S., Montgomery, M. L., & Reys, R. E. (1981). Calculators in testing situations: Results and implications from national assessment. *Arithmetic Teacher, 23,* 34-37.

Charness, N., Schumann, C., & Boritz, G. (1992). Training older adults in word-processing: Effects of age, training technique, and computer anxiety, *International Journal of Technology and Aging, 5*(1), 79-106.

Chazan, D. (1996). Algebra for all students? *Journal of Mathematical Behavior, 15*, 455-477.

Chui, L. & Henry, L. (1990). Development and validation of the mathematics anxiety scale for children. *Measurement and Evaluation in Counseling and Development, October 23*(3), 121-127.

Clark, V. & Chambers, S. (1989). Gender-based factors in computing enrollments and achievement: Evidence from a study of tertiary students. *Journal of Educational Computing Research, 5*(4), 409-429.

Colley, A., Gale, M., & Harris, T. (1994). Effects of gender role identity and experience on computer attitude components. *Journal of Educational Computing Research, 10*(2), 129-137.

Connelly, J. (1994). Why I fear and loathe my computer. *Fortune,* Nov., 263.

Creswell, J. (1994). *Research design: Qualitative and quantitative approaches*. Thousand Oaks: Sage publications.

D'Ailly, H. & Bergering, A. (1992). Mathematics anxiety and mathematics avoidance behavior: A validation study of two MARS factor-derived scales. *Educational and Psychological Measurement, 52,* 369-377.

Dalgleish, T. (1995). Performance on the emotional Stroop task in-groups of anxious, expert, and control subjects: A comparison of computer and card presentation formats. *Cognition and Emotion, 9*(4), 341-362.

Dalton, D. & Hannafin, M. (1987). The effects of word processing on written composition. *Journal of Educational Research, 80*(6), 338-342.

Davis, B. (1999). Encircling mathematics knowing and mathematics knowledge. *Journal of Research on Mathematics Education, 30*(1), 111-117.

Dossey, J. (1998). How school mathematics functions: Perspectives from the NAEP 1990 and 1992 assessments. *Mathematics Workshop at University of Northern Iowa.*

Ethington, C. A. & Wolfe, L. M. (1986). A structural model of mathematics achievement for men and women. *American Educational Research Journal, 23*(1), 65-75.

Fennema, E. & Sherman, J. A. (1979). Fennema-Sherman Mathematics Attitude Scale: instrument designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education,* 7, 324-326.

Folkman, S. & Lazarus, R. S. (1988). *Manual for the ways of coping questionnaire.* Palo Alto, CA: Consulting Psychologists Press, now published by MIND GARDEN.

Frieze, I., Sales, E., & Smith, C. (1991). Considering the social context in gender research: The impact of college students' life stage. *Psychology-of-Women-Quarterly, 15*(3), 371-392.

Gardner, D. G., Discenza, R., & Dukes, R. L. (1993). The measurement of computer attitudes and computer literacy levels of prospective educators. *Journal of Research on Computers in Education, 9,* 381-389.

Glasgow, B. & Reyes, J. (1998). The authority of the calculators in the minds of college students. *School Science and Mathematics*, *98*(7), 383-388

Gressard, C. & Loyd, B. (1987). An investigation of the effects of math anxiety and sex on computer attitudes, *School Science and Mathematics, 87*(2), 125-135.

Griswold, W. (1994). Them versus it: Coping with the writing technophobe in the technical writing classroom. *Technical Communication: Journal of the Society for Technical Communication, 41*(3), 500-503.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal of Research in Mathematics Education, 17*, 83-99.

Hembree, R. & Dessart, D. J. (1984). Effects of hand-held calculators in precollege mathematics education: A meta-analysis. *Journal for Research in Mathematics Education, 17*, 83-99.

Hettinger, J. (1999). Tackling the TIMSS. *Techniques, 74*(2), 30-32.

Hignite, M. & Echternacht, L. (1992). Assessment of the relationships between the computer attitudes and the computer literacy levels of prospective educators. *Journal of Research on Computing in Education, 24*(3), 381-391.

Ho, H., Senturk, D., Lam, A. G., Zimmer, J. M., Hong, S., Okamoto, Y., Chiu, S., Nakazawa, Y., & Wang, C. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education, 31,* 362-379.

Jackson, C. D. & Leffingwell, R. J. (1999). The role of instructor in creating math anxiety in students from kindergarten through college. *Mathematics Teacher, 92*, 583–586.

Kazelskis, R. (1998). Some dimensions of mathematics anxiety: A factor analysis across instruments. *Educational and Psychological Measurement, 58*(4), 623-633.

Langford, S., Bell, R. & Ellias, J. (1994). Computerized versus standard personality measures: Equivalency, computer anxiety, and gender differences. *Computers in Human Behavior, 10*(4), 497-510.

Lazarus, R. S. (1993). Coping research: Past, present, and future. *Psychosomatic Medicine,* 55, 234-247.

Lazarus, R. S. (1999). Hope: An emotion and a vital coping resource against despair. *Social Research, 66*, 653-672.

Lightbody, P. & Durndell, A. (1996). The masculine image of careers in science and technology: fact or fantasy? *British Journal of Educational Psychology, 66*(2), 231-246.

Ma, X. (1999). A meta-analysis of the relationship between anxiety in mathematics and achievement in mathematics. *Journal for Research in Mathematics Education, 30,* 520-540.

National Council of Teachers of Mathematics. (1986). *Position statement: Calculators in the mathematics classroom.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1998). *Position statement: Calculators and the education of youth.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Norwood, K. S. (1994). The effect of instructional approach on mathematics anxiety and achievement. *School Science & Mathematics, 94*, 248-255.

Postman, N. (1992). *Technopoly: The surrender of culture to technology*. New York: Knopf.

Reys, B. J. & Arbaugh, F. (2001). Clearing up the confusion over calculator use in grades k-5. *Teaching Children Mathematics, 8*, 90-95.

Richardson, F. C. & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*, 551-554.

Ruthven, K. (1990). The influence of graphic calculator use on translation from graphic to symbolic forms. *Educational Studies in Mathematics, 21,* 431-450.

Schwarzer, R. & Schwarzer, C. (1996). A critical survey of coping instruments. *Handbook of coping.* New York: Wiley.

Shashaani, L. (1994). Gender-differences in computer experience and its influence on computer attitudes. *Journal of Educational Computing Research, 11*(4), 347-367.

Suinn, R., Taylor, S., & Edwards, R. (1988). Suinn mathematics anxiety rating scale for elementary school students (MARS-E): Psychometric and normative data. *Educational and Psychological Measurement, 48*, 979-986.

Texas Instruments Incorporated, (1999). *Texas Instruments graphing calculator guidebook.* Menasha, WI. Banta Book Group.

Thomasson, S. J. (1993). The effects of the graphing calculator on the achievement and attitude of college students enrolled in elementary algebra. *Dissertation Abstracts International, 53*, 3835A.

Tobias, S., & Weissbrod, C. (1980). Anxiety and mathematics: An update. *Harvard Educational Review, 50*, 63-70.

Tolias, G. (1993). The effects of using graphing technology in college precalculus. *Dissertation Abstracts International, 54*, 1274A-1275A.

Vogel, L. (1994). Explaining performance on P&P versus computer mode of administration for the verbal section of the Graduate Record Exam. *Journal of Educational Computing Research, 11*(4), 369-383.

Waxman, H. & Huang S. (1996). Classroom instruction differences by level of technology use in middle school mathematics. *Journal of Educational Computing Research, 14*(2), 157-169.

Wheatley, G., Clements, D., & Battista, M. (1990). Calculators and constructivism. *Arithmetic Teacher,* Oct., 22-23.

Wigfield, A. & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology,* 80, 210-216.

Worthington, V. & Zhao, Y. (1999). Existential computer anxiety and changes in computer technology: What past research on computer anxiety has missed. *Journal of Educational Computing Research, 20*(4), 299-317.

Appendix A

Supplementary Tables

The following data represent the results of

Bootstrap of sets of 50 sampled with replacement:

Coding: C17 = stand deviation, C11 = calculator stress, C13 = math anxiety,

C15 = confrontational coping behavior

Set 1

Regression Analysis

```
The regression equation is
C17 = 6.22 - 0.0349 C11 - 0.0299 C13 - 0.0387 C15
```

Predictor	Coef	StDev	T	P
Constant	6.2200	0.4630	13.43	0.000
C11	-0.03488	0.01291	-2.70	0.010
C13	-0.029908	0.008920	-3.35	0.002
C15	-0.03870	0.01136	-3.41	0.001

```
S = 0.5858      R-Sq = 53.6%     R-Sq(adj) = 50.5%
```

Set 2

Regression Analysis

```
The regression equation is
C17 = 5.91 - 0.0559 C11 - 0.0133 C13 - 0.0372 C15
```

Predictor	Coef	StDev	T	P
Constant	5.9118	0.8048	7.35	0.000
C11	-0.05586	0.02320	-2.41	0.020
C13	-0.01330	0.01144	-1.16	0.251
C15	-0.03721	0.01468	-2.53	0.015

```
S = 0.7213      R-Sq = 25.0%     R-Sq(adj) = 20.1%
```

Set 3

Regression Analysis

The regression equation is
C17 = 6.15 - 0.0248 C11 - 0.0430 C13 - 0.0380 C15

Predictor	Coef	StDev	T	P
Constant	6.1539	0.6686	9.20	0.000
C11	-0.02475	0.01687	-1.47	0.149
C13	-0.04301	0.01287	-3.34	0.002
C15	-0.03802	0.01584	-2.40	0.021

S = 0.6994   R-Sq = 47.8%   R-Sq(adj) = 44.4%

Set 4

Regression Analysis

The regression equation is
C17 = 5.50 - 0.0146 C11 - 0.0275 C13 - 0.0414 C15

Predictor	Coef	StDev	T	P
Constant	5.5001	0.5963	9.22	0.000
C11	-0.01457	0.01761	-0.83	0.412
C13	-0.02752	0.01261	-2.18	0.034
C15	-0.04140	0.01592	-2.60	0.012

S = 0.7642   R-Sq = 40.1%   R-Sq(adj) = 36.2%

Set 5:

Regression Analysis

The regression equation is
C17 = 6.44 - 0.0407 C11 - 0.0193 C13 - 0.0665 C15

Predictor	Coef	StDev	T	P
Constant	6.4430	0.7387	8.72	0.000
C11	-0.04066	0.01948	-2.09	0.042
C13	-0.01930	0.01091	-1.77	0.084
C15	-0.06647	0.01530	-4.34	0.000

S = 0.7112   R-Sq = 44.7%   R-Sq(adj) = 41.1%

Set 6

Regression Analysis

The regression equation is
C17 = 6.07 - 0.0383 C11 - 0.0163 C13 - 0.0566 C15

Predictor	Coef	StDev	T	P
Constant	6.0664	0.6221	9.75	0.000
C11	-0.03827	0.01864	-2.05	0.046
C13	-0.01627	0.01047	-1.55	0.127
C15	-0.05658	0.01465	-3.86	0.000

S = 0.7673 R-Sq = 45.9% R-Sq(adj) = 42.3%

Set 7

Regression Analysis

The regression equation is
C17 = 6.38 - 0.0600 C11 - 0.0163 C13 - 0.0455 C15

Predictor	Coef	StDev	T	P
Constant	6.3750	0.4929	12.93	0.000
C11	-0.06001	0.01341	-4.47	0.000
C13	-0.016335	0.007819	-2.09	0.042
C15	-0.04551	0.01361	-3.34	0.002

S = 0.5774 R-Sq = 52.8% R-Sq(adj) = 49.7%

Set 8

Regression Analysis

The regression equation is
C17 = 6.64 - 0.0492 C11 - 0.0333 C13 - 0.0411 C15

Predictor	Coef	StDev	T	P
Constant	6.6391	0.5510	12.05	0.000
C11	-0.04916	0.01645	-2.99	0.004
C13	-0.033333	0.009878	-3.37	0.002
C15	-0.04110	0.01392	-2.95	0.005

S = 0.7139 R-Sq = 53.8% R-Sq(adj) = 50.8%

Set 9

Regression Analysis

The regression equation is
C17 = 7.58 - 0.0837 C11 - 0.0148 C13 - 0.0647 C15

Predictor	Coef	StDev	T	P
Constant	7.5789	0.8752	8.66	0.000
C11	-0.08373	0.02033	-4.12	0.000
C13	-0.01477	0.01611	-0.92	0.364
C15	-0.06467	0.01939	-3.33	0.002

S = 0.8359 R-Sq = 44.5% R-Sq(adj) = 40.9%

Set 10

Regression Analysis

The regression equation is
C17 = 5.84 - 0.0725 C11 + 0.0031 C13 - 0.0373 C15

Predictor	Coef	StDev	T	P
Constant	5.8406	0.7426	7.87	0.000
C11	-0.07250	0.01938	-3.74	0.001
C13	0.00309	0.01574	0.20	0.845
C15	-0.03726	0.01995	-1.87	0.068

S = 0.8201 R-Sq = 28.0% R-Sq(adj) = 23.3%

Set 11

Regression Analysis

The regression equation is
C17 = 6.17 - 0.0567 C11 - 0.0139 C13 - 0.0449 C15

Predictor	Coef	StDev	T	P
Constant	6.1743	0.6872	8.98	0.000
C11	-0.05671	0.01819	-3.12	0.003
C13	-0.01393	0.01058	-1.32	0.194
C15	-0.04485	0.01535	-2.92	0.005

S = 0.6853 R-Sq = 36.5% R-Sq(adj) = 32.3%

Set 12

Regression Analysis

The regression equation is
C17 = 6.06 - 0.0736 C11 - 0.0151 C13 - 0.0166 C15

Predictor	Coef	StDev	T	P
Constant	6.0592	0.7241	8.37	0.000
C11	-0.07362	0.02118	-3.48	0.001
C13	-0.01507	0.01360	-1.11	0.274
C15	-0.01661	0.01952	-0.85	0.399

S = 0.8274 R-Sq = 29.7% R-Sq(adj) = 25.2%

Set 13

Regression Analysis

The regression equation is
C17 = 5.61 - 0.0315 C11 - 0.0384 C13 - 0.0045 C15

Predictor	Coef	StDev	T	P
Constant	5.6094	0.8038	6.98	0.000
C11	-0.03154	0.01962	-1.61	0.115
C13	-0.03844	0.01212	-3.17	0.003
C15	-0.00452	0.01571	-0.29	0.775

S = 0.7359 R-Sq = 22.1% R-Sq(adj) = 17.1%

Set 14

Regression Analysis

The regression equation is
C17 = 5.85 - 0.0292 C11 - 0.0349 C13 - 0.0189 C15

Predictor	Coef	StDev	T	P
Constant	5.8493	0.9299	6.29	0.000
C11	-0.02923	0.02349	-1.24	0.220
C13	-0.03488	0.01505	-2.32	0.025
C15	-0.01893	0.01889	-1.00	0.322

S = 0.7729 R-Sq = 20.4% R-Sq(adj) = 15.2%

Set 15

Regression Analysis

```
The regression equation is
C17 = 5.62 - 0.0272 C11 - 0.0301 C13 - 0.0292 C15
```

Predictor	Coef	StDev	T	P
Constant	5.6179	0.5911	9.50	0.000
C11	-0.02722	0.01536	-1.77	0.083
C13	-0.030134	0.009355	-3.22	0.002
C15	-0.02916	0.01382	-2.11	0.040

```
S = 0.6534        R-Sq = 37.2%      R-Sq(adj) = 33.1%
```

Set 16

Regression Analysis

```
The regression equation is
C17 = 5.55 - 0.0085 C11 - 0.0409 C13 - 0.0318 C15
```

Predictor	Coef	StDev	T	P
Constant	5.5472	0.7675	7.23	0.000
C11	-0.00848	0.02156	-0.39	0.696
C13	-0.04091	0.01195	-3.42	0.001
C15	-0.03179	0.01862	-1.71	0.094

```
S = 0.7934        R-Sq = 35.6%      R-Sq(adj) = 31.4%
```

Set 17

Regression Analysis

```
The regression equation is
C17 = 5.42 - 0.0197 C11 - 0.0313 C13 - 0.0323 C15
```

Predictor	Coef	StDev	T	P
Constant	5.4231	0.6898	7.86	0.000
C11	-0.01969	0.02045	-0.96	0.341
C13	-0.03132	0.01173	-2.67	0.010
C15	-0.03235	0.01474	-2.19	0.033

```
S = 0.7363        R-Sq = 30.8%      R-Sq(adj) = 26.3%
```

Set 18

Regression Analysis

```
The regression equation is
C17 = 5.43 - 0.0225 C11 - 0.0198 C13 - 0.0455 C15

Predictor        Coef       StDev          T        P
Constant       5.4272      0.6740       8.05    0.000
C11          -0.02247     0.01787      -1.26    0.215
C13          -0.01978     0.01011      -1.96    0.056
C15          -0.04547     0.01719      -2.65    0.011

S = 0.7076      R-Sq = 30.2%      R-Sq(adj) = 25.6%
```

Set 19

Regression Analysis

```
The regression equation is
C17 = 6.01 - 0.0610 C11 - 0.0217 C13 - 0.0318 C15

Predictor        Coef       StDev          T        P
Constant       6.0065      0.5957      10.08    0.000
C11          -0.06095     0.01620      -3.76    0.000
C13         -0.021735    0.009526      -2.28    0.027
C15          -0.03180     0.01393      -2.28    0.027

S = 0.6688      R-Sq = 42.5%      R-Sq(adj) = 38.7%
```

Set 20

Regression Analysis

```
The regression equation is
C17 = 6.95 - 0.0621 C11 - 0.0317 C13 - 0.0312 C15

Predictor        Coef       StDev          T        P
Constant       6.9453      0.6639      10.46    0.000
C11          -0.06213     0.01753      -3.54    0.001
C13          -0.03165     0.01102      -2.87    0.006
C15          -0.03122     0.01491      -2.09    0.042

S = 0.6978      R-Sq = 44.7%      R-Sq(adj) = 41.1%
```

Appendix B

Survey Instrument

Mathematics Survey

Mathematics Survey Your participation is requested as part of the research project that I am conducting for my doctoral degree in Educational Administration from Oklahoma State University. The purpose of this study is to ascertain information about mathematics and the use of graphing calculators. If you agree to participate in the following survey, completion of the survey will constitute consent. Time required to complete the survey will be between 10-15 minutes during the class period. Should you choose not to participate, no penalty will result. Complete anonymity will be provided. Analysis of the data will be reported as an aggregate score.

If you have questions about this research, please feel free to contact any of the following:

Jerry Hicks, 01-44-1638 583788, the Researcher

Adrienne Hyle, 001-405-744-9893, OSU dissertation advisor

Sharon Bacher, 001-405-744-5700, OSU Institutional Review Board

Please fill in the blank or circle the most appropriate answer:

Age: ____M or F (circle) Nationality: ________Grade in class: A B C D F

Ethnicity: (a) White (b) Black (c) Hispanic (d) Asian (e) Other _________

HOW DO YOU USE CALCULATORS

1. Not at all 2. Not very much 3. A little 4. Much 5. Very much

1. Would you prefer to use a calculator to take a test? 1 2 3 4 5
2. Would you prefer to use a calculator to do homework? 1 2 3 4 5
3. Would you prefer not to use a calculator to do the finals? 1 2 3 4 5
4. How would an unfamiliar calculator affect test taking? 1 2 3 4 5
5. How would an unfamiliar calculator affect homework? 1 2 3 4 5
6. How would a familiar calculator affect your finals? 1 2 3 4 5
7. Would you choose a basic calculator compared to a graphing calculator for taking a test? 1 2 3 4 5
8. Would you choose a basic calculator compared to a graphing calculator for doing homework? 1 2 3 4 5
9. Would you choose a graphing calculator compared to a basic calculator for the finals? 1 2 3 4 5

DO YOU WORRY:

1. Not at all 2. Not very much 3. A little 4. Much 5. Very much

10. How much do you worry about how well you are doing in school? 1 2 3 4 5
11. How much do you worry about how you are doing in mathematics? 1 2 3 4 5
12. If you are absent from school and you miss a math assignment, are you unconcerned ? 1 2 3 4 5

13. Compared to other subjects, how much do you worry about
your progress in mathematics? 1 2 3 4 5

14. Do you worry about using any calculator? 1 2 3 4 5

15. Do you worry that your calculator at school is not like the one at home? 1 2 3 4 5

16. Do you worry about being able to operate a graphing calculator? 1 2 3 4 5

17. Do you worry about adding with mental math or paper and pencil? 1 2 3 4 5

18. Do you worry about adding problems with a calculator? 1 2 3 4 5

19. Do you worry about subtracting with mental math or paper and pencil? 1 2 3 4 5

20. Do you worry about subtracting problems with a calculator? 1 2 3 4 5

21. Do you worry about multiplying with mental math or paper and pencil? 1 2 3 4 5

22. Do you worry about multiplying problems with a calculator? 1 2 3 4 5

23. Do you worry about dividing with mental math or paper and pencil? 1 2 3 4 5

24. Do you worry about dividing problems with a calculator? 1 2 3 4 5

25. Do you worry when reading a cash register receipt after purchase? 1 2 3 4 5

WHAT IS YOUR MATH CONFIDENCE?

1. Not at all 2. Not very much 3. A little 4. Much 5. Very much

26. Does mathematics scare you at all? 1 2 3 4 5

27. Are you at ease during mathematics tests? 1 2 3 4 5

28. Are you at ease during mathematics class? 1 2 3 4 5

29. Would you be scared taking advanced mathematics? 1 2 3 4 5

30. Do you feel confident during a mathematics test? 1 2 3 4 5

31. Do calculators make mathematics easier? 1 2 3 4 5

32. How much would you use a graphing calculator for this problem?

    Finding Trigonometry ratio 1 2 3 4 5

33. Mathematics does not make you feel uncomfortable, restless, or irritable. 1 2 3 4 5

34. You get a sinking feeling trying written problem-solving questions. 1 2 3 4 5

35. Mathematics usually makes you feel impatient and nervous. 1 2 3 4 5

36. Mathematics is easy. 1 2 3 4 5

37. Your mind goes blank when working math. 1 2 3 4 5

38. Mathematics tests scare you. 1 2 3 4 5

39. Problem solving is easy. 1 2 3 4 5

40. Do graphing calculators scare you? 1 2 3 4 5

WHAT IS YOUR ANXIETY LEVEL WHEN:

1. Not at all 2. Not very much 3. A little 4. Much 5. Very much

41. Walking into a math class makes me feel anxious. 1 2 3 4 5

42. Listening to another student explain a math formula is easy to follow. 1 2 3 4 5

43. Asked to compare your answer with a partner? 1 2 3 4 5

44. Asked to calculate and demonstrate a problem at the board? 1 2 3 4 5

45. Watching a teacher work an algebraic equation on the blackboard and comparing my answers? 1 2 3 4 5

46. Taking an exam (quiz) in a math course? 1 2 3 4 5

47. Receiving your final mathematics results in the mail? 1 2 3 4 5

48. Getting ready to study for a mathematics test? 1 2 3 4 5

49. Given a non-graded homework assignment? 1 2 3 4 5

50. Seeing a page full of problems to work for a grade? 1 2 3 4 5

IN A STRESSFUL SITUATION

1. Not used 2. Used somewhat 3. Used a little 4. Used quite a bit 5. Used a great deal

51. I did something that I didn't think would work, but at least I was doing something. 1 2 3 4 5
52. I criticized my ability on the graphing calculator. 1 2 3 4 5
53. I hoped for a miracle. 1 2 3 4 5
54. I went along with fate; sometimes I just have bad luck. 1 2 3 4 5
55. I went on as if I knew how to operate the graphing calculator. 1 2 3 4 5
56. I looked for how the graphing calculator would help me eventually. 1 2 3 4 5
57. I daydreamed more than usual. 1 2 3 4 5
58. I expressed anger to the person(s) who caused the problem. 1 2 3 4 5
59. I tried to forget the whole thing. 1 2 3 4 5
60. I apologized for not using the graphing calculator. 1 2 3 4 5
61. I let myself say or do something to let my feelings show. 1 2 3 4 5
62. I realized that I hadn't learned the operations of the graphing calculator. 1 2 3 4 5
63. I tried to make myself feel better about using the graphing calculator by making excuses. 1 2 3 4 5
64. I took a big chance or did something very risky to solve the problem. 1 2 3 4 5
65. I generally avoided being with a group. 1 2 3 4 5
66. I didn't let it get to me; I refused to think too much about specific calculator function. 1 2 3 4 5

67. I was prepared for the worst when answering questions on slope of a line while using the graphing calculator 1 2 3 4 5

68. I stood my ground and refused to use the graphing calculator. 1 2 3 4 5

69. I blamed other people for my difficulty. 1 2 3 4 5

70. I promised myself that things would be different next time. 1 2 3 4 5

71. I wished that the situation would go away or somehow be over. 1 2 3 4 5

72. I tried to see other students' point of view about using graphing calculators and adapt. 1 2 3 4 5

Appendix C

Regression Analysis

The following are two regression analyses to show that the plot had to be linear and not cubic or quadratic.

Regression Analysis

The regression equation is

Grade = 4.29 - 0.00017 cs_MA -0.000622 CSsq -0.000359 MAsq CS_MA is the product of the Cal Stress times Math anxiety,

The other two are squares of the indiviual scores.

Note that none of the p values were even close to significant.

Predictor Coef StDev T P

Constant 4.2939 0.2939 14.61 0.000

cs_MA -0.000174 0.001306 -0.13 0.894

CSsq -0.0006216 0.0008990 -0.69 0.491

MAsq -0.0003594 0.0004909 -0.73 0.467

S = 0.7828 R-Sq = 27.3% R-Sq(adj) = 24.2%

Analysis of Variance

Source DF SS MS F P

Regression 3 16.5502 5.5167 9.00 0.000

Residual Error 72 44.1208 0.6128

Total 75 60.6711

Source DF Seq SS

cs_MA 1 16.2210

CSsq 1 0.0008

MAsq 1 0.3284

Unusual Observations

Obs cs_MA Grade Fit StDev Fit Residual St Resid

3 1311 3.0000 2.5692 0.3374 0.4308 0.61 X

5 1161 3.0000 2.6804 0.4774 0.3196 0.52 X

16 2562 2.0000 1.4140 0.3213 0.5860 0.82 X

25 1530 1.0000 2.5812 0.1411 -1.5812 -2.05R

31 1007 2.0000 2.8847 0.3655 -0.8847 -1.28 X

55 2310 1.0000 1.5647 0.3119 -0.5647 -0.79 X

64 1189 1.0000 2.9600 0.1154 -1.9600 -2.53R

66 1566 4.0000 2.4505 0.1653 1.5495 2.03R

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.

Regression Analysis

The regression equation is

Grade = 4.10 -0.000007 ma_con -0.000000 Consq -0.000000 Escsq -0.000608 ma_esc

Predictor Coef StDev T P

Constant 4.0961 0.2686 15.25 0.000

ma_con -0.00000656 0.00001689 -0.39 0.699

Consq -0.00000024 0.00000035 -0.70 0.488

Escsq -0.00000002 0.00000005 -0.40 0.694

ma_esc -0.0006077 0.0002569 -2.37 0.021

S = 0.7640 R-Sq = 31.7% R-Sq(adj) = 27.9%

Analysis of Variance

Source DF SS MS F P

Regression 4 19.2330 4.8082 8.24 0.000

Residual Error 71 41.4381 0.5836

Total 75 60.6711

Source DF Seq SS

ma_con 1 14.5788

Consq 1 0.6678

Escsq 1 0.7205

ma_esc 1 3.2659

Unusual Observations

Obs ma_con Grade Fit StDev Fit Residual St Resid

5 49923 3.0000 2.6707 0.5443 0.3293 0.61 X

16 107604 2.0000 1.1649 0.3588 0.8351 1.24 X

31 19133 2.0000 2.4540 0.3639 -0.4540 -0.68 X

55 80850 1.0000 1.6851 0.4322 -0.6851 -1.09 X

64 34481 1.0000 2.9428 0.1224 -1.9428 -2.58R

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.

Regression Analysis

The regression equation is

Grade = 3.82 -0.000851 ma_esc

Predictor Coef StDev T P

Constant 3.8177 0.2187 17.46 0.000

ma_esc -0.0008510 0.0001910 -4.46 0.000

S = 0.8040 R-Sq = 21.2% R-Sq(adj) = 20.1%

Analysis of Variance

Source DF SS MS F P

Regression 1 12.833 12.833 19.85 0.000

Residual Error 74 47.838 0.646

Total 75 60.671

Unusual Observations

Obs	ma_esc	Grade	Fit	StDev Fit	Residual	St Resid
25	1440	1.0000	2.5923	0.1200	-1.5923	-2.00R
31	2173	2.0000	1.9685	0.2356	0.0315	0.04 X
64	1148	1.0000	2.8408	0.0946	-1.8408	-2.31R
71	874	1.0000	3.0739	0.0974	-2.0739	-2.60R

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.

Appendix D

Institutional Review Board Approval

Oklahoma State University
Institutional Review Board

Protocol Expires: 2/5/2004

Date: Thursday, February 06, 2003 IRB Application No ED0363

Proposal Title: COPING MECHANISMS EMPLOYED IN THE USE OF GRAPHING CALCULATORS AND THEIR RELATINSHIP TO THE LINEAR AND AROUSAL THEOERIES OF ANXIETY

Principal
Investigator(s):

Adrienne Hyle
314 Willard Hall
Stillwater, OK 74078

Jerry Hicks
106 Willard
Stillwater, OK 74078

Reviewed and
Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

Dear PI :

Your IRB application referenced above has been approved for one calendar year. Please make note of the expiration date indicated above. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved projects are subject to monitoring by the IRB. If you have questions about the IRB procedures or need any assistance from the Board, please contact Sharon Bacher, the Executive Secretary to the IRB, in 415 Whitehurst (phone: 405-744-5700, sbacher@okstate.edu).

Sincerely,

Carol Olson

Carol Olson, Chair
Institutional Review Board

VITA

Jerry William Hicks

Candidate for the Degree of

Doctor of Education

Thesis: COPING MECHANISMS EMPLOYED IN THE USE OF GRAPHING CALCULATORS AND THEIR RELATIONSHIP TO THE LINEAR AND AROUSAL THEORIES OF ANXIETY

Major Field: Educational Administration

Biographical:

Personal Data: Born in Bristol, Tennessee, on November 14, 1947, the son of Columbus and Alice Hicks.

Education: Graduated from Holston Valley High School, Bristol Tennessee in May 1965; received a Bachelor of Science degree in Biology from East Tennessee State University, Johnson City, Tennessee in December, 1969: received a Masters of Arts degree in Science Education from East Tennessee State University, Johnson City in August, 1970; completed requirements for the Doctor of Education degree at Oklahoma State University, Stillwater, Oklahoma in December, 2003.

Experience: Worked as a radarman for the United States Navy; worked as a mathematics teacher for Bristol, Tennessee; worked as a Dean and teacher for Bristol College; worked as an educator in the Department of Defense Schools for the past twenty two years.

Professional Memberships: National Education Association; Overseas Education Association